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WATER SUPPLY AND WATER QUALITY CONTROL
STUDY, PAT MAYSE RESERVOIR, SANDERS
CREEK, TEXAS. STUDY OF NEEDS AND VALUE
OF STORAGE FOR MUNICIPAL AND INDUSTRIAL
WATER SUPPLY AND WATER QUALITY CONTROL

Public Health Service
Dallas, Texas

March 1965

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**WATER SUPPLY
AND
WATER QUALITY CONTROL STUDY
PAT MAYSE RESERVOIR
SANDERS CREEK, TEXAS**

**Study of Needs and Value of Storage
For Municipal and Industrial Water Supply
and Water Quality Control**

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**U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas
MARCH 1965**

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WATER SUPPLY
AND
WATER QUALITY CONTROL STUDY
PAT MAYSE RESERVOIR
SANDERS CREEK, TEXAS

Abstract

A survey has been made which discloses the need for and value of storage for municipal and industrial purposes in Pat Mayse Reservoir. The study revealed no foreseeable need for storage for water quality control purposes at this site. These conclusions are based on results of economic and demographic studies. Future needs are based on projected population and industrial growth.

Prepared for
DEPARTMENT OF THE ARMY
U.S. Army Engineer District
Tulsa, Oklahoma

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

MARCH 1965

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I. INTRODUCTION

Request and Authority

The District Engineer of the Corps of Engineers, Tulsa District, requested in a letter dated January 17, 1964, ". . . that the Public Health Service make the necessary studies to determine the need for providing releases from Pat Mayse Reservoir for downstream quality control on Sanders Creek. . . ." Also, the 100-year water supply needs of the area which could be served by Pat Mayse Reservoir were requested. 1/

This study has been made in accordance with (1) the Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare, relative to Title III, Public Law 85-500 as amended by Public Law 87-88, and (2) the Federal Water Pollution Control Act as amended (33 U.S.C. 466 a(b)).

Purpose and Scope

The purpose of this study was to determine water requirements to the year 2020 and 2070 for municipal, industrial, and water quality control purposes for the area adjoining Pat Mayse Reservoir located on Sanders Creek in northeast Texas, and how these needs may be met.

A reevaluation of the original report "Sanders, Big Pine, and Acworth Reservoirs Study, Sanders, Big Pine, and Collier Creeks, Texas" is made, extracting that part applicable to the Sanders Reservoir, now called Pat Mayse Reservoir. The projected economic developments and anticipated needs for water supply are extended to the year 2070.

Acknowledgments

The assistance and cooperation of agencies and individuals who provided data for this report are gratefully acknowledged. These include:

Forrest and Cotton, Consulting Engineers, Dallas, Texas
Bureau of Business Research, University of Texas, Austin, Texas
Chamber of Commerce, Bonham, Texas
Chamber of Commerce, Clarksville, Texas
Chamber of Commerce, Paris, Texas
City of Clarksville, Texas
City of Bonham, Texas
City of Paris, Texas

Texas State Department of Health
Attmore E. Griffin, Consulting Engineers, Pompton Plains,
New Jersey
Industrial Development Department, Texas Power and Light
Company
Texas Water Commission

II. SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. Pat Mayse Reservoir is a proposed multipurpose Corps of Engineers project to be located on Sanders Creek approximately four miles above its mouth on Red River. The project will be in Lamar County, about fifteen miles north of Paris, Texas. (See figure III-1).
2. The quality of water to be impounded in the Pat Mayse Reservoir is of poorer mineral quality than the present existing source in Lake Crook. Water from Pat Mayse Reservoir, with adequate treatment, will be acceptable for municipal and industrial purposes. Reference is made to chemical analyses in tables V-1 and V-2.
3. The study area, consisting of Lamar, Fannin, Red River, and Delta Counties, Texas grouped in the northeastern section of the State along the Oklahoma border, (see figure III-1), had a 1960 population of 79,656.
4. The major city within the study area is Paris (1960 population 20,977), followed in size by Bonham (1960 population 7,357), and Clarksville (1960 population 3,561), located in Lamar, Fannin, and Red River Counties, respectively.
5. The city of Paris currently discharges its municipal wastes, which receive secondary treatment, into Pine Creek, a tributary to Red River.
6. The major industrial water user in the area is a large food processing company at Paris. Its wastes are currently disposed of by spray irrigation.

Conclusions

1. Although the study area has experienced a population decline in the past twenty years, industrial development is expected to reverse this trend. The population for the four-county area is projected as 188,000 for the year 2020, and 265,000 for the year 2070.
2. Paris, Lamar County, the principal anticipated user of storage in the proposed Pat Mayse project, is expected to receive a large portion of the population.

The growth rate is expected to decrease slightly after 1970. This rapid projected population growth is expected to follow the quite likely location of a large food processor or similar industry in the city. Projected populations for 2020 and 2070 are 103,000 and 148,000, respectively.

3. Projected Paris area water demands for municipal and industrial use are approximately 34 million gallons daily (mgd) in 2020, reaching approximately 44 mgd in 2070.
4. The value of benefits derived from storage for supplying municipal and industrial needs from the proposed Pat Mayse Reservoir on Sanders Creek is estimated to be \$214,500 annually. This estimate is based on the cost of the most likely alternate source of water in absence of the project. Since the reservoir is needed as soon as possible, no discounting of the benefits is made.
5. No need for providing releases from Pat Mayse Reservoir for downstream quality control on Sanders Creek is anticipated in the foreseeable future.
6. Continued use of Pine Creek as a receiving stream for treated municipal wastes and projected industrial waste discharges will create a stream quality problem.
7. The maintenance of stream quality in the study area can be achieved by the transport of waste water to Red River where the streamflow exceeds the dilution requirements. The proposed project should provide water which, after conventional treatment, will be acceptable for municipal and industrial uses.

III. PROJECT DESCRIPTION

General

Pat Mayse Reservoir, a multipurpose project for flood control and conservation storage, will be located on Sanders Creek 4.4 miles upstream from the confluence with the Red River. (See figure III-1 at the back of this report.) The dam will control a drainage area of 175 square miles. The proposed water supply storage for municipal and industrial use will be 109,000 acre-feet with a safe yield of 55 mgd. ^{1/}

Streamflow

The project will control the entire flow from the watershed upstream from the project site. The stream will be essentially dry from the project site to its mouth at Red River, this distance is very small, amounting to approximately 6 miles, and no planned releases will be made from the reservoir.

Water Quality

As shown in table V-1, Sanders Creek has high concentrations of both iron (maximum 3.8 milligrams per liter (mg/l)) and manganese (maximum 2.2 mg/l), probably resulting from local geologic conditions; but, impoundment should reduce maximums by dilution and mixing with low concentration runoff, as well as iron and manganese having the capability of precipitating naturally from the water. Water stored in the proposed project should provide raw water which can reasonably be made acceptable for municipal and industrial use.

IV. STUDY AREA DESCRIPTION

Location and Boundaries

Located in northeast Texas, the study area consists of Lamar, Fannin, Red River, and Delta Counties. (See figure III-1.) The area is bordered on the north by Oklahoma and to the south by the Sulphur River drainage basin. Drainage of the area is to the Red River by four creeks, the western section by Sanders and Bois d' Arc Creeks, the central section by Pine Creek, and the eastern section by Big Pine Creek.

Geography and Topography

The landscape of the area is generally rolling hills, sloping to flat valley plains at the northern perimeter. The soils of the area are in a transition region of the Blackland Prairie from the west to East Texas Timberland soils to the east. The land is especially suitable for farming, having as the principal crops cotton, corn, rye, peanuts, and hay.

Climate

Climatological characteristics are conducive to agriculture-based industries due to a growing season of 241 frost-free days, a mean temperature of 64° F., and rainfall of approximately 43 inches per year. ^{2/}

Principal Communities and Industries

The principal city within the study area is Paris (1960 population of 20,977), Lamar County, followed in size by Bonham (1960 population 7,357), Fannin County. The principal economic activities in the study area are agriculture, manufacturing, particularly food and kindred products, with food processing being the most significant water-user in the area.

The city of Paris has demonstrated its interest in the project by requesting all storage available (dependable yield - 55 mgd) for municipal and industrial water supply. ^{1/}

V. WATER RESOURCES OF THE STUDY AREA

Ground Water

There are several water-bearing aquifers in the study area; however, in all formations the availability is low, averaging only 30 percent porosity. The Woodbine Formation yielded 1.25 mgd for municipal use at Bonham, Fannin County, in 1959. This represents the major use from the formation and the water meets quality standards. ^{2/} The Blossom Sands yielded 0.30 mgd in 1959 from two wells for the city of Clarksville. The water yielded was from fresh to slightly saline. In general, ground water from the Blossom Sand is high in sodium bicarbonate, high in dissolved solids content, and is soft. The Nacatock sand in southwestern Red River County yielded 0.15 mgd for industrial purposes in 1959. The availability of water from this aquifer is unknown, due to insufficient data on sand thickness and where water levels are high enough to provide sufficient drawdown without dewatering the sands. ^{4/}

Surface Water

The several creeks in the study area have watersheds similar in area and runoff characteristics. The area average rainfall of 43 inches per year makes each of these creeks a potential source of water for municipal, industrial, irrigation, or quality control uses. The only utilization of these creeks at present is by Paris, Lamar County, whose impoundments, Lake Crook and Lake Gibbons, are located in the upper reaches of Pine Creek. Lake Crook is the existing source of water supply for the city of Paris with a yield of 5.0 mgd. ^{3/} Other creeks offering potential reservoir sites are Sanders Creek in Lamar County, Big Pine and Collier Creeks in Red River County, and Bois d' Arc Creek in Fannin County. Runoff characteristics of Sanders Creek are shown in Appendix A.

The quality of Sanders Creek as shown in table V-1 is less than the quality of Pine Creek (table V-2).

In comparing the quality, the difference in mg/l is particularly noted in calcium, magnesium, sulfates, chlorides, and total dissolved solids. The chemical characteristics of water from Lake Crook and Sanders Creek are such that after proper treatment the water quality will meet accepted standards. ^{3/}

Table V-1

Chemical Analysis
Sanders Creek, Texas
1958 - 1959

Date of Sample Type of Sample	11/26/58 Composite	3/14/59 Grab	4/27/59 Grab	6/25/59 Grab
Calcium (Ca)*	84	--	--	--
Magnesium (Mg)*	16	--	--	--
Iron (Fe)*	1.6	1.63	--	3.8
Manganese (Mn)*	2.2	0	0.06	0
Sodium (Na)*	41	--	--	--
Carbonate (CO ₃)*	0	--	--	--
Bicarbonate (HCO ₃)*	285	--	--	--
Sulfate (SO ₄)*	51	--	--	--
Chlorides (Cl)*	62	17	--	19
Fluoride (F)*	0.4	--	--	--
Nitrate (NO ₃)*	<0.4	--	--	--
Dissolved Solids*	424	54	375	112
Total Alkalinity as CaCO ₃ *	234	--	--	--
Hardness*	292	133	139	112
pH	7.2	7.0	7.0	6.1

*Milligrams per liter.

Source: Forrest and Cotton, Inc., 5/, and Attmore E. Griffin 6/

Table V-2

Results of Chemical Analyses
City of Paris Water Supply
1954 - 1960

Location	Mean Pine Creek	Lake Crook	Lake Crook	Treated	Treated
Date	11-24-58	1-54	4-60	1-54	4-60
Calcium (Ca)*	26	14	14	26	34
Magnesium (Mg)*	5	3	3	5	4
Iron (Fe)*	2	4.2	1.5	0.1	0.14
Manganese (Mn)*	0.6	<0.5	--	<0.5	0.5
Sodium (Na)*	5	8	7	9	7
Carbonate (CO ₃)*	0	--	--	--	--
Bicarbonate (HCO ₃)*	100	--	--	--	--
Sulfate (SO ₄)*	11	14	19	42	54
Chlorides (Cl)*	7	7	10	11	13
Fluoride (F)*	0.4	.3	.1	.8	.5
Nitrate (NO ₃)*	<0.4	<0.4	<0.4	<0.4	<0.4
Dissolved Residue*	153	145	80	114	145
Total Alkalinity as CaCO ₃ *	82	40	24	45	34
Hardness*	88	48	49	86	100
pH	6.7	7.7	7.4	7.8	8.0

*Milligrams per liter.

Source: Texas State Department of Health 2/

VI. THE ECONOMY

An economic analysis was made of the study area. The resulting projections serve as a basis for estimating future municipal and industrial water requirements and anticipated waste discharges.

PresentEmployment

Table VI-1 shows employment patterns of the four-county study area for 1940, 1950, and 1960. The most significant change in employment was a large decrease in agriculture, accompanied by a smaller increase in manufacturing and all other employment. The agricultural losses from all four counties in the study area amounted to a total of about 17,000 workers from this segment of the economy. Agricultural losses accounted for most of the more than 18,000 lost from the labor force between 1940 and 1960. In 1960, agriculture accounted for 21 percent of the labor force of the study area compared to 3 percent for the State of Texas. Manufacturing employment is slightly above the Texas level, accounting for 15.7 percent of the labor force in the study area, compared to 14.9 percent for the State of Texas.

Table VI-1

Study Area Employment
1940, 1950, and 1960

	<u>1940</u>		<u>1950</u>		<u>1960</u>	
	<u>Number</u>	<u>Per-</u> <u>cent</u>	<u>Number</u>	<u>Per-</u> <u>cent</u>	<u>Number</u>	<u>Per-</u> <u>cent</u>
Agriculture	22,315	47.8	14,005	39.5	5,960	21.4
Mining	62	.1	62	.2	51	.2
Manufacturing	1,301	2.8	2,482	7.0	4,370	15.7
Food and Kindred	(474)		(528)		(721)	
Service and Other	14,853	32.2	17,504	49.3	16,130	57.9
Unemployed*	7,970	17.1	1,414	4.0	1,334	4.8
Total Labor Force	46,501	100.0	35,467	100.0	27,845	100.0
Total Population	134,116		105,101		79,656	

*1940 unemployed includes those on emergency public works.

Source: Bureau of the Census 8/

Agriculture

Employment in agriculture decreased more than 50 percent between 1950 and 1960. During the same time period, the total value of farm products sold remained about constant. As shown in table VI-2, livestock sales are becoming increasingly important in the study area. In 1959, livestock accounted for more than 50 percent of the total value of farm products sold.

Table VI-2

Study Area Agricultural Statistics 1944, 1949, 1954, and 1959

	<u>1944</u>	<u>1949</u>	<u>1954</u>	<u>1959</u>
Number of Farms	12,978	11,521	8,959	6,652
Acres of Cropland Harvested (1,000)	632	613	493	396
Value of Crops Sold*	15,805	22,272	13,156	13,850
Value of Livestock Sold*	7,012	6,185	7,136	14,619
Value of All Farm Products Sold*	22,817	28,457	20,292	28,469

*All values in 1,000's of 1960 dollars.

Source: Bureau of the Census 9/

Manufacturing

Study area manufacturing employment more than tripled between 1940 and 1960. Most of this increase has been a result of new industries locating in the area. These industries include: manufacture of machinery, electrical equipment, apparel, rubber and glass products, furniture, and wood and paper products. Not included in the data in table VI-1 is the Campbell Soup plant in Paris. This plant was scheduled to begin in 1964, initially employing 750 workers. Ultimate employment of this plant is expected to be 1,200 persons. 10/

Population

Sixty percent of the 1960 study area population was classified rural, compared to 25 percent for Texas, and 30 percent for the Nation. As shown in table VI-3, study area urban population has increased each census between 1930 and 1950. A slight loss of urban population was experienced between 1950 and 1960. However, the net loss of 62,000 rural dwellers since 1930 has been largely responsible for the decline in total population.

Table VI-3

Population - Urban, Rural, and Paris
for the Study Area - 1930, 1940, 1950, and 1960

	1930		1940		1950		1960	
	Number	Per- cent	Number	Per- cent	Number	Per- cent	Number	Per- cent
Urban	24,256	18.1	31,659	23.6	33,045	31.4	32,185	40.4
Paris	(15,640)		(18,678)		(21,643)		(20,977)	
Rural	109,497	81.9	102,457	76.4	72,056	68.6	47,471	59.6
Total	133,753	100.0	134,116	100.0	105,101	100.0	79,656	100.0

Source: Bureau of the Census 8/

Future

The national movement of industry from big cities to small towns and rural areas, plus the availability of an adequate water supply, labor force, transportation facilities, and desirable climate should be a further incentive to industrial development of the region.

Most of the study area's growth is expected to center in the manufacturing segment of the economy, much of which growth is already planned. The largest increment of the future manufacturing growth of the study area is expected in food and kindred processing. Growth of food processing will be accelerated with the opening of the Campbell Soup plant, ultimately expected to employ 1,200 or more persons. As increasing vegetable crops are harvested in the study area, it is likely that one or two smaller canneries may be established. Because of the study area's location in respect to the Dallas wholesale apparel market and the availability of women for work, expansion is expected in the apparel industry. Machinery and metal industries presently located in the study area also have a good potential for growth. Additional manufacturing in this sector may include production of transportation equipment parts, agricultural equipment, and fabricated metal goods. With the expansion of the industrial base, service employment is expected to increase. 10/

Paris, where the food processor ~~is~~ located, will continue to be the major trade center for the study area. This development is contingent upon the availability of an adequate and acceptable water supply. Population projections for the study area and for Paris to 2020 and 2070 are shown in table VI-4.

Table VI-4

Projected Population for the
Study Area and Paris - 2020 and 2070

<u>Year</u>	<u>Study Area</u>	<u>Paris</u>
1960	79,655	20,977
2020	188,000	103,000
2070	265,000	148,000

VII. WATER REQUIREMENTS

General

Municipal and industrial water use patterns in the past serve as guides to project future needs.

Municipal

Municipal water use includes residential, public, commercial, and minor industrial uses which are served by organized public water supply systems and are reflected in a per capita use figure. Included are distribution system losses, water treatment plant losses, and evaporation.

Present

The cities of Bonham, Fannin County, and Clarksville, Red River County, utilize ground water; while Paris, Lamar County, utilizes surface water. The surface water supply for Paris comes from Lake Crook on Pine Creek. ^{9/} The historical water use on a per capita basis for the city of Paris is shown in table VII-1.

Table VII-1

Historical Water Use
Paris, Texas

<u>Year</u>	<u>Average Use</u> <u>(mgd)</u>	<u>Per Capita Use</u> <u>(gpd)</u>
1925	0.95	63.4
1930	0.96	61.1
1935	0.95	55.6
1940	1.23	69.3
1945	1.89	93.6
1950	1.91	106.5
1955	2.56	109.9
1956	2.79	120.8
1957	2.44	101.2
1958	2.49	101.1
1959	2.40	98.5
1960	2.24	95.3
1961	2.34	98.9
1962	2.73	112.5
1963	3.47	140.0

Source: Public Health Service ^{11/}, Paris Chamber of Commerce ^{12/}
Texas Water Commission ^{13/}

Future

Water use on a per capita basis is expected to increase during the first 50 years, reaching 150 gallons per capita day (gpcd) by the year 2020, and remain at this level through the year 2070. These projected water needs are presented in table VII-2 and exclude the water use of the food processing industries. The future water needs of the small industrial water users, as developed in Chapter VI, as well as the service industries, are included in the municipal water requirements.

Table VII-2

Future Municipal Water Requirements
Paris, Texas

<u>Year</u>	<u>Average Use (mgd)</u>	<u>Per Capita Use (gpd)</u>
2020	15.5	150
2070	22.2	150

Industrial

Industrial water requirements include the demands for water supply exerted by the principal water-using industries.

Due to the location of a food processing plant in Paris, which is a large water user, water requirements for this industry were considered separately. The water requirements of the major food processor and water requirements of minor food processors as they are expected to develop are combined and shown in table VII-3.

Table VII-3

Industrial Water Use - Food Processing
Paris, Texas, 1960 - 2070

<u>Year</u>	<u>Average Use (mgd)</u>
1960	0
1961	2
1965	10
1970	18
2020	18
2070	22

Source: Public Health Service 11/, and
Paris Chamber of Commerce 12/

VIII. WATER QUALITY CONTROL REQUIREMENTS

Under the provisions of the Federal Water Pollution Control Act, as amended, consideration must be given to the inclusion of storage for regulation of streamflow to control water quality in any reservoir being planned by a Federal agency. Storage and release of this water are not to be provided as a substitute for adequate treatment of wastes at the source.

Appraisal of Water Quality

Appraisal of water quality is based on indicators which are used to evaluate stream conditions. Biochemical oxygen demand (BOD) is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by, the stream environment). The quality of municipal return flow is based on assumed per capita contributions of 0.25 pounds per day of ultimate first stage BOD. The dissolved oxygen content of streams is a significant factor in the maintenance of an environment necessary for propagation of fish and other aquatic life and for the avoidance of nuisance conditions.

Existing Conditions

The city of Paris currently discharges municipal wastes (2.0 mgd) after secondary treatment into Pine Creek below the Lake Crook Dam. ^{14/} The wastes from the food processing plant are being initially handled by spray irrigation with projected plans for treatment and final discharge into Pine Creek. The quantity of flow in Pine Creek is inadequate to assimilate these waste discharges of the Paris area.

Future Conditions

The increased discharges of treated wastes from both municipal and industrial sources at Paris will result in Pine Creek being a stream whose flow is principally waste water. This flow would be characterized by an absence of dissolved oxygen, being devoid of fish and other aquatic life.

IX. WATER SUPPLY AND WATER QUALITY CONTROL PLAN

The demand for municipal and industrial water supply on Pat Mayse Reservoir, on Sanders Creek in the study area, is by the city of Paris. The total projected demand is 33.5 mgd in 2020 and 44.2 mgd in 2070. This demand is below the safe yield of Pat Mayse Reservoir which is 55 mgd.

The existing source of supply for the city of Paris, Lake Crook, is to be used as a receiving reservoir. Under this type of operation, the 5 mgd of yield will not be available.

The cities of Bonham and Clarksville, included in the study area, can meet all of their municipal and industrial water demand from the existing ground water sources and planned surface water supplies.

Bonham is planning a reservoir on Timber Creek north of the city that will provide a dependable yield of 7.0 mgd.

The Soil Conservation Service is planning a reservoir on Langford Creek in which Clarksville will participate, obtaining 1.0 mgd to augment their ground water supply. 9/

The continued use of Pine Creek as a receiving stream for the treated waste of the study area will result in increased flow but with a water quality unacceptable for further use. This is based on a demand or draft-on-storage of 24,950, 51,800, and 60,200 acre-feet per year needed for dilution of the treated waste resulting from the use of 13.6, 28.2, and 33.5 mgd respectively during the years 1965, 1990, and 2020. The effluent is assured to have 85 percent of the BOD removed and would be discharged to Pine Creek. The exceedence interval for the low flows of 13,650 acre-feet per year will be 19 years out of 20. This problem can be overcome by transporting the treated waste to the Red River where the minimum low monthly flow that is exceeded 19 out of 20 years is 98,500 acre-feet and exceeds the above dilution requirements. Should an alternate be selected, as outlined below, for the quality maintenance of Pine Creek, a more detailed study would be required for determining the low flow requirements.

Alternate plans for water quality control would be provision of annual draft-on-storage in Pat Mayse Reservoir. This plan would be contingent upon one of two methods of solution; the first being installation of a pipeline and related equipment for pumping dilution water from Pat Mayse Reservoir to Pine Creek, and the second,

installation of a pipeline for gravity transport of wastes to Sanders Creek downstream from Pat Mayse Reservoir. Neither alternative would be less costly than the pollution abatement measure for Pine Creek previously suggested.

No need for storage or release of water from the proposed Pat Mayse Reservoir to preserve water quality in Sanders Creek is anticipated in the foreseeable future.

X. BENEFITS

Senate Document No. 97 (87th Congress, 2nd sess.) makes the following statement concerning evaluation of benefits of municipal and industrial water supply storage in Federal reservoirs:

"The amount water users should be willing to pay for such improvements in lieu of foregoing them affords an appropriate measure of this value. In practice, however, the measure of the benefit will be approximated by the cost of achieving the same results by the most likely alternative means that would be utilized in the absence of the project."

This alternative cost method was used to evaluate storage for municipal and industrial use in the project reservoir. The value determined in this way is considered a minimum annual benefit.

After investigation of various possibilities, a single-purpose reservoir at the site of Pat Mayse was adopted as the most reasonable alternative to the project. The single-purpose project was assumed to have a yield equal to the yield expected from the storage to be provided for municipal and industrial water supply purposes in the proposed multipurpose reservoir.

The method of calculation used for the benefit evaluation is shown in Appendix B. Since the reservoir is needed as soon as possible, no discounting of the benefit is made. On this basis for calculations, the value of the average annual benefits will be \$214,500.

XI. BIBLIOGRAPHY

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APPENDIX A

Estimated Monthly and Annual Flows in Acre-Feet - Sanders Creek at Pat Mayse Damsite

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1937	-	-	-	-	-	-	-	-	-	2,477	9,447	6,127	18,050
1938	18,540	45,610	35,440	20,300	3,314	5,258	2,511	1,392	226	0	22	208	132,800
1939	347	3,935	7,258	20,070	1,621	1,624	3,330	331	0	69	296	387	39,270
1940	440	712	682	14,650	39,080	14,740	11,320	2,914	754	367	5,929	12,920	104,500
1941	2,610	6,294	3,422	28,540	31,060	38,340	6,137	631	6	7,295	5,038	4,915	134,300
1942	1,648	2,846	8,704	72,990	18,450	16,550	103	2,341	2,652	1,886	5,524	8,011	141,700
1943	2,541	2,059	9,808	8,741	15,940	16,380	1,494	2,795	359	434	770	516	61,830
1944	1,330	18,640	5,498	4,735	24,790	8,503	605	107	960	103	2,208	5,322	72,800
1945	4,153	47,510	60,700	12,950	3,437	46,340	8,275	1,589	7,039	15,370	2,354	1,753	211,500
1946	11,020	26,210	19,730	8,952	36,200	10,600	2,358	7,381	3,598	2,089	48,410	27,150	203,700
1947	6,964	2,293	14,730	27,960	12,830	4,040	1,670	3,374	1,063	561	1,718	12,930	90,130
1948	5,899	22,620	12,830	3,997	27,740	1,974	9,658	1,615	196	676	351	569	88,120
1949	34,080	18,930	10,500	12,120	7,716	7,702	2,951	524	716	4,177	563	1,293	101,300
1950	27,560	43,530	5,930	2,612	38,580	3,586	21,850	13,340	21,370	2,170	738	2,176	183,400
1951	1,601	17,570	1,341	3,792	4,800	37,120	3,356	480	950	918	1,339	478	73,740
1952	26	643	6,722	41,750	8,836	2,168	42	48	276	95	1,345	1,396	63,350
1953	1,616	785	5,314	32,350	15,910	833	2,025	1,783	635	20	1,363	3,598	66,230
1954	7,954	2,902	391	2,957	36,060	2,273	1,440	73	79	21,110	2,424	1,557	79,220
1955	3,499	6,942	16,400	12,630	3,203	734	5,629	688	3,219	2,559	2,243	1,607	59,350
1956	1,680	13,020	2,063	871	3,348	38	0	0	0	184	706	343	22,250
1957	446	2,507	5,447	65,520	70,820	41,850	4,630	93	8,230	1,857	33,780	8,827	244,000
1958	17,990	5,681	19,360	18,210	32,810	4,505	1,212	236	288	678	815	260	102,000
1959	0	625	1,738	498	1,121	3,404	15,500	924	516	3,043	6,038	13,510	46,920
1960	14,430	7,504	6,623	3,136	2,430	5,002	1,632	2,350	3,390	3,422	1,609	20,560	72,090
1961	8,319	7,442	18,070	5,693	5,463	2,081	1,470	932	1,938	1,430	4,465	15,750	73,050
1962	12,810	4,939	5,377	11,690	7,890	16,300	454	3,364	11,820	-	-	-	74,640
Mean	7,500	12,470	11,360	17,510	18,140	11,680	4,386	1,972	2,811	2,920	5,580	6,087	102,400

Source: Corps of Engineers 2/

APPENDIX B

Benefit Calculations

Pat Mayse Reservoir Project

No discounting due to an immediate need for storage.

Most reasonable alternative: single-purpose reservoir with a yield from storage of 44.2 mgd.

First cost	\$5,300,000
Interest during construction @ 4%	<u>159,000</u>
Total Investment	\$5,459,000

Amortize private investment for 25 years @ 4%

$$\$5,459,000 \times .06401 = \$349,000$$

Convert to equivalent Federal investment to provide for same annual payment.

$$\text{Present worth of 1 per period @ } 3 \frac{1}{8}\% = 17.17308$$

Then equivalent Federal investment =

$$\$349,000 \times 17.17308 = \$5,993,000$$

Amortize Federal investment for 100 years @ 3 1/8%

$$\text{Annual Cost} = \$5,993,000 \times .03276 = \$196,300$$

$$\text{Annual Operation and Maintenance} = \underline{18,200}$$

$$\text{Annual Benefits} \quad \$214,500$$

